

# Mechanisms of Maladaptation to Physical Exercise in Moscow Schoolchildren

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Schoolchildren overloaded with learning do not have time to exercise and often have hypodynamia. Namely they show primarily such negative effects of hypokinesia as incorrect posture, insufficient muscular development, and obesity. Lack of physical activity has acute effect on the formation of the cardiovascular system in schoolchildren. Here we assess the level of physical development and the degree of adaptation to physical exercise in schoolchildren of different age and gender.

**Key Words:** *schoolchildren; physical development; mechanisms of maladaptation*

Long-term observations confirm that maintaining and strengthening the physical health of students as well as prevention of hypodynamia are directly related to their physical activity. Sedentary lifestyle, especially among urban schoolchildren, leads to retardation of growth and functional development of boys and girls, reduced adaptive capacity of the young organism, and increased frequency and duration of diseases.

Here we studied possible mechanisms of maladaptation to exercise in the schoolchildren.

## MATERIALS AND METHODS

The study included 15,067 Moscow schoolchildren (7760 boys and 7307 girls) at the age of 7-17 years.

Anthropometric parameters were recorded. Height and weight were measured, body mass index (BMI) was calculated, BP and HR were recorded. Vital lung capacity (VLC) was evaluated with USPTS-01 spirometer.

The following functional tests were performed: for motor coordination (throw a ball against a wall and catch the rebound at a distance of 3 m), Stange's test

(a breath holding on an inspiration in the sitting position), flexibility (palms down below the floor level) [1,2].

Physical performance was assessed by push-ups and exercises to work the abdominals (number of times within 30 sec).

Index of physical development was calculated on a computer using special software [1,2].

The data were processed using Student's *t* test, factor analysis (ANOVA), and calculation of linear correlation coefficients.

## RESULTS

Exercise capacity in schoolchildren significantly increased with age. VLC also increases; its significant increase occurs in boys starting from the age of 13 years (Table 1). BP also grows and from the age of 13 years systolic BP in girls is stabilized at about 120 mm Hg, while in boys it continues to increase and attains ~130 mm Hg by the age of 17 years. Diastolic BP increases with age almost identical in boys and girls; small peak increase was noted in girls at the age of 16 years (Table 1). HR decreases with age to 84 bpm on average in boys and 82 bpm in girls by the age of 17 years (Table 1). Parameters of the test for resistance to hypoxia (Stange's test) increase with age, this in-

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**TABLE 1.** VLC, HR, BP and Stange's Test Parameters in Schoolchildren of Different Age and Gender

Age, years	VLC		HR		SBP		DBP		Stange's test	
	b	g	b	g	b	g	b	g	b	g
7	1515	1378	92	94	103	102	63	63	29	28
8	1736	1611	91	91	106	104	64	64	34	33
9	1961	1816	90	90	109	107	65	66	39	36
10	2147	2012	88	89	110	109	66	66	44	39
11	2370	2263	89	91	114	113	68	68	47	43
12	2690	2545	86	90	117	116	68	70	52	45
13	2998	2762	86	88	120	118	69	71	53	47
14	3479	2920	86	88	125	119	71	72	59	50
15	3806	3022	85	86	128	119	71	73	63	51
16	4108	3138	81	84	129	120	72	79	67	54
17	4249	3207	84	82	131	121	73	72	66	56

**Note.** SBP, systolic BP; DBP, diastolic BP. *b*, boys; *g*, girls.

crease was more pronounced in boys, which correlates with the dynamics of VLC (Table 1). Flexibility of boys was lower than in girls; it reached the minimum in 11-13-year-old boys, but then increased and stabilized at the age of 16-17 years, but at a far lower level than in girls (Table 1). At the same time, indicators of motor coordination were better in 17-year-old boys (Table 1).

All this except BP reflects normal physiological maturation. However, a significant increase in BMI was observed with age, boys had higher BMI than girls starting from the age of 13 years (Fig. 1). This attests to increased proportion of overweight people among older schoolchildren compared to the younger ones with predominance of boys among them.

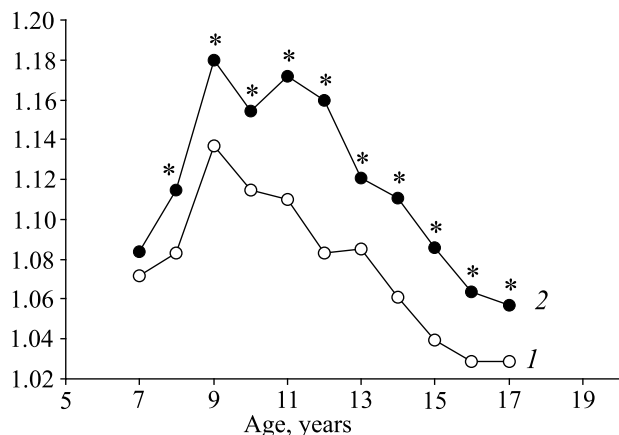
Considering age-dependent changes in BMI in children and adolescents we have calculated relative values of BMI for every age and gender (Fig. 1). WHO recommendations (WHO Multicentre Growth Reference Study Group, 2006) served as reference standards. In all age groups, average BMI among Moscow adolescents exceeded standards. We recorded significant difference from normal values in the girls aged 7-14 years and in the 8-16-old boys (Fig. 1). Since the age of 8 years, BMI in boys significantly surpassed that in girls indicating higher prevalence of overweight and obesity among boys. We observed maximum values of relative BMI in girls at 9-11 years, in boys, at 9-12 years of age. In this case, a slight decline occurred in 10 years possibly corresponding to the prepubertal period. We reported the most intensive increase in relative BMI in 8-9 year-old girls and boys.

Overweight is a risk factor for chronic non-infectious diseases. The increase in BMI in the surveyed group results in increased systolic BP and reduction in diastolic BP at rest, which may indicate an imbalance of regulation of the cardiovascular system in boys.

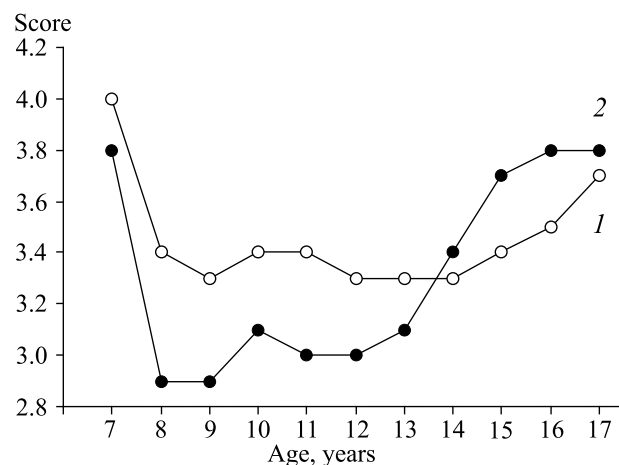
We have calculated the index of physical health (IPH), which is a generalized indicator of physical development and health integrating the assessment of the major physiological systems and physical qualities. For estimation, well-defined set of measurements and test procedures was used. IPH was calculated with a specially developed computer program and assessed by IPH rating scale, where the highest level of physical health is 6.0 points, the minimum, 0.1 points.

In Moscow schoolchildren, IPH decreased at the age of 7-8 years (Fig. 2). A year later (9-10 years), an intense increase in the relative values of BMI was observed, which reflects an increase in the number of people with overweight and obesity in children and adolescents. Thus, the decrease in IPH precedes changes in the health status of children. IPH increases starting from the age of 13 years in girls and 15-16 years in boys, *i.e.* one year before normalization of the relative BMI.

During the first school year, IPH sharply decreased in all children; in boys this decrease was more pronounced, which may point to expressed maladaptation of Moscow schoolchildren to sharply increased physical load and mental stress. Later, BMI gradually increased (in girls starting from the age of 14 years and in boys most markedly from 13 to 15 years of age). At the age of 17 years, the index of physical



**Fig. 1.** Relative BMI as a function of age and gender. 1) girls; 2) boys. \* $p < 0.05$  compared with girls.



**Fig. 2.** IPH as a function of age and gender. 1) girls; 2) boys.

development was somewhat higher boys, but in both boys and girls it remained below the values observed before the school life. That is why despite increased index of physical development, senior schoolchildren may have a greater risk of cardiovascular and other diseases. In particular, the lack of significant differences in the indices of physical development in boys at the age of 16 and 17 years may indicate this indirectly.

We studied the distribution of IPH by Moscow administrative districts. In all districts except East and West districts, IPH in girls was higher than in boys. The highest IPH rates were recorded in Northwest, Southwest, and Northern administrative districts. This may be due to better environmental conditions and/or socio-economic conditions in these districts, which, in turn, requires more careful study.

Thus, physical activity of schoolchildren positively correlated with IPH and negatively with BMI.

This suggests that the leading mechanism underlying changes in the number of overweight children and adolescents is their physical activity. At the same time, gender differences in BMI indicate the existence of genetic factors influencing this phenomenon and territorial differences reflect the influence of environmental factors. In general, a more detailed study of mechanisms of overweight and obesity in the children and adolescents of Moscow is necessary.

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